NORTH CENTRAL FOREST EXPERIMENT STATION
Research Note NC-267
1992 FOLWELL AVE. ST. PAUL, MN 55108 FOREST SERVICE-U.S.D.A.
1981

TREE BIOMASS ESTIMATES FOR MINNESOTA'S ASPEN-BIRCH FOREST SURVEY UNIT

Gerhard K. Raile, *Associate Mensurationist,*
and **Pamela J. Jakes**, *Associate Resource Analyst*

ABSTRACT.—Live tree biomass estimates are presented for five counties of northeastern Minnesota. Tree biomass is given in green tons for forest types and species groups.

KEY WORDS: Volume, tops and limbs, cull, growing-stock, boles.

An increasing demand for wood fiber, advances in wood technology, and other changes in the Nation's forest resources have spurred interest in complete tree utilization. Such developments require a measure of total tree volume that includes more than just merchantable volume. Estimating tree biomass is the first step in estimating the total wood volume on commercial forest land.

Tree biomass, including the bark, is made up of five components:

1. **Growing-stock boles**.—the above-ground volume in growing-stock trees from a 1-foot stump to a variable 4-inch top diameter outside the bark (t.d.o.b.).
2. **Growing-stock tops and limbs**.—the above-ground volume in growing-stock trees from a 1-foot stump, excluding the growing-stock bole.
3. **Cull tree boles**.—the above-ground volume in cull trees from a 1-foot stump to a 4-inch t.d.o.b.
4. **Cull tree tops and limbs**.—the above-ground volume of cull trees from a 1-foot stump, excluding the cull bole.
5. **1- to 5-inch d.b.h. trees**.—the total above-ground volume of all trees 1 to 5 inches in diameter at breast height.

In Minnesota, estimates of tree biomass on commercial forest land outside the National Forests were obtained during the fourth Minnesota Forest Inventory (dated 1977). The recently completed Superior National Forest Inventory (dated 1979) has provided tree biomass estimates for that forest. Information from the two surveys has been combined to estimate the tree biomass on commercial forest land in the Aspen-Birch Forest Survey Unit (Carlton, Cook, Koochiching, Lake, and St. Louis Counties).

METHOD

Tree biomass was estimated with the following method: First, net cubic foot volumes were converted to green tons by using weight conversion factors for each species (Markwardt 1930). The weight of the bole bark was then computed using bark correction factors for individual species, the gross volume of the bole, and an average bark weight of 37 pounds per cubic foot. Tops and limbs for growing-stock and cull trees were estimated as 45 percent of the gross bole volume (Young *et al.* 1976). Finally, the biomass for trees less than 5 inches d.b.h. was computed from a regression equation fit to Young's tree weight table (Young *et al.* 1976). This regression equation uses d.b.h. to estimate total above-ground biomass as 80 percent of the above- and below-ground biomass.

FINDINGS

Tree biomass in the Aspen-Birch Forest Survey Unit was estimated at 250.8 million green tons in 1978, or about 43.5 green tons per acre of commercial forest land. Sixty-five percent of the Unit's biomass is made up of growing-stock trees (table 1). Biomass in 1- to 5-inch d.b.h. trees accounts for more than one-quarter of the Unit's total tree biomass. The distribution of tree biomass among the five components differs for softwoods and hardwoods (fig. 1).

Hardwood tree species make up most of Minnesota's tree biomass. Of the 149.3 million green tons of hardwood tree biomass, 108.9 million green tons are in aspen and paper birch. Softwood tree biomass is concentrated in balsam fir and black spruce. More than 50 percent of the black spruce tree biomass is in 1- to 5-inch d.b.h. trees.

The 250.8 million green tons of tree biomass in the Aspen-Birch Unit equal 11.8 billion cubic feet. Tree biomass in growing-stock boles totals 5.3 billion cubic feet. Data from the fourth Minnesota Forest Inventory and the Superior National Forest Inventory show that net growing-stock volume in the Unit is 4.4 billion cubic feet. The difference between biomass cubic foot volume in growing-stock boles and the net growing-stock volume in cubic feet is the bark component of biomass. Bark accounts for almost 20 percent of the growing-stock bole biomass.

Forty-eight percent of the biomass is in stands less than 51 years old (table 2). The importance of small diameter trees in supplying biomass is shown in the distribution of biomass among diameter classes (table 3). Twenty-six percent of the total biomass is made up of trees less than 5 inches d.b.h., 18 percent is made up of trees 5.0-6.9 inches d.b.h., and 19 percent is made up of trees 7.0-8.9 inches d.b.h. (table 3).

LITERATURE CITED

Markwardt, L. J. 1930. Comparative strength properties of woods grown in the United States. U.S. Department of Agriculture, Technical Bulletin 158, 38 p.

Young, H. E., L. E. Hoar, and T. C. Tryon. 1976. A forest biomass inventory of some public land in Maine. p. 285-302. *In* Oslo Biomass Studies. Life Science and Agricultural Experiment Station, University of Maine, Orono, Maine.

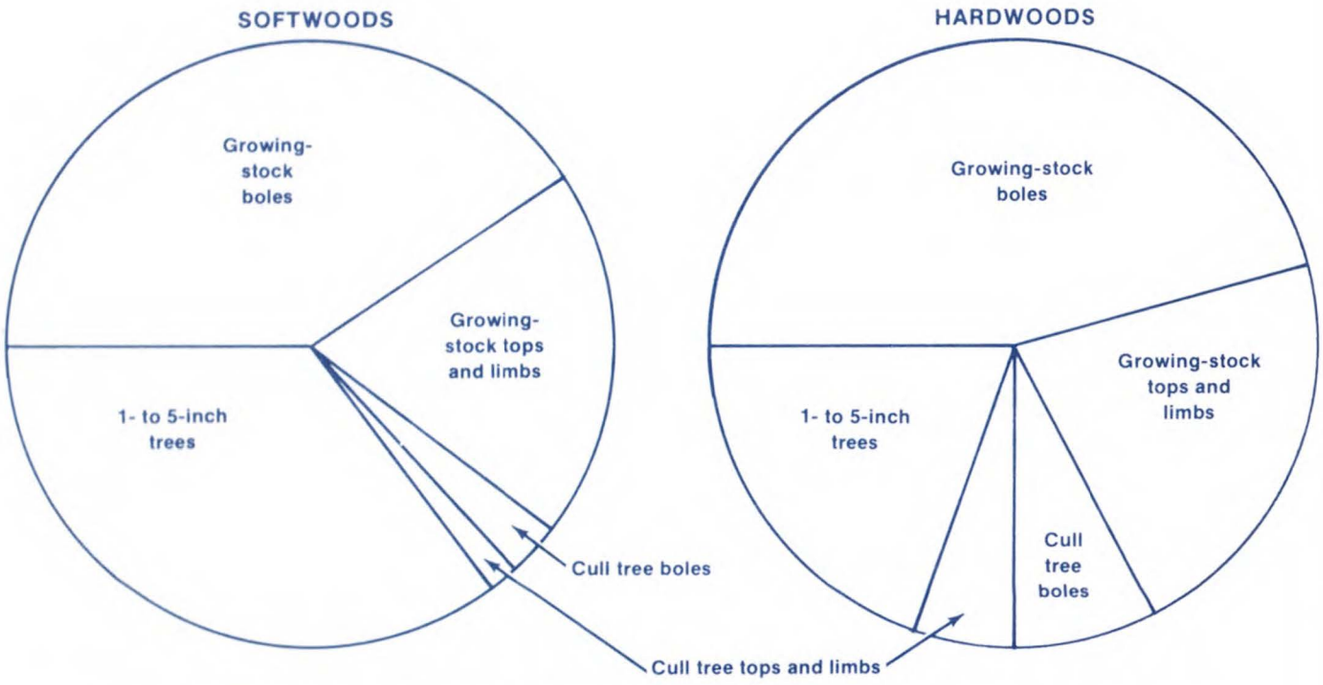

Figure 1.—*Distribution of biomass among components, softwoods and hardwoods, Aspen-Birch Unit, Minnesota, 1978.*

Table 1.--All live biomass by species and component, Aspen-Birch Unit, Minnesota, 1978

Species	Biomass component: All components	Growing-stock: Boles	Growing-stock: Tops and limbs	Cull: Boles	Cull: Tops and limbs	1- to 5-inch trees	Biomass component: All components	Growing-stock: Boles	Growing-stock: Tops and limbs	Cull: Boles	Cull: Tops and limbs	1- to 5-inch trees
	Thousand green tons						Thousand cubic feet					
SOFTWOODS:												
White pine	3,199	1,966	926	129	72	106	175,754	108,683	51,297	7,143	3,904	4,727
Red pine	7,276	4,512	2,076	72	38	578	353,234	220,180	101,916	3,557	1,819	25,762
Jack pine	7,624	4,659	2,167	290	159	349	321,131	195,845	90,688	12,341	6,747	15,510
White spruce	4,865	2,612	1,228	53	34	938	265,150	148,644	69,698	3,046	1,929	41,833
Black spruce	25,383	8,200	3,820	247	143	12,973	1,342,012	505,407	235,202	15,194	8,824	577,385
Balsam fir	36,008	13,628	6,363	734	412	14,871	1,629,183	623,207	290,359	33,721	19,046	662,850
Tamarack	5,555	1,968	994	262	152	2,179	244,504	86,021	43,395	11,450	6,683	96,955
Northern white-cedar	11,483	3,966	2,011	920	718	3,868	695,319	273,765	138,607	62,647	48,150	172,150
Other softwoods	47	11	5	2	2	27	2,246	574	281	88	49	1,254
Total	101,440	41,522	19,590	2,709	1,730	35,889	5,028,533	2,162,326	1,021,443	149,187	97,151	1,598,426
HARDWOODS:												
Select white oaks	348	189	86	14	10	49	12,773	6,706	3,020	512	368	2,167
Select red oaks	623	333	153	44	32	61	22,654	11,659	5,372	1,611	1,272	2,740
Other red oaks	--	--	--	--	--	--	--	--	--	--	--	--
Hickory	--	--	--	--	--	--	--	--	--	--	--	--
Yellow birch	920	314	149	221	200	36	35,494	11,646	5,531	8,559	8,165	1,593
Hard maple	6,087	1,900	910	754	554	1,969	245,741	71,984	34,430	29,435	22,226	87,666
Soft maple	4,715	823	416	558	405	2,513	208,424	35,632	17,910	24,745	18,079	112,058
Ash	11,270	4,929	2,399	392	295	3,255	488,619	210,671	102,554	17,207	13,210	144,977
Balsam poplar	11,546	5,802	2,733	648	452	1,911	575,561	294,779	139,004	33,241	23,402	85,135
Paper birch	39,436	18,335	8,541	2,460	1,533	8,567	1,664,275	759,303	354,243	103,581	65,220	381,928
Bigtooth aspen	1,533	763	366	174	108	122	72,899	36,525	17,396	8,379	5,202	5,397
Quaking aspen	67,959	33,005	15,954	5,288	4,054	9,658	3,222,458	1,576,987	761,830	256,358	197,174	430,109
Basswood	1,557	847	393	69	62	186	74,227	40,645	18,851	3,390	3,081	8,260
Elm	2,675	1,390	644	222	170	249	106,905	54,489	25,206	8,983	7,128	11,099
Select hardwoods	31	2	1	1	1	26	1,379	73	40	37	27	1,202
Other hardwoods	117	13	6	17	16	65	5,251	549	270	758	746	2,928
Noncommercial species	534	--	--	45	32	457	23,855	--	--	1,993	1,455	20,407
Total	149,351	68,645	32,751	10,907	7,924	29,124	6,760,515	3,111,648	1,485,657	498,789	366,755	1,297,666
All species	250,791	110,167	52,341	13,616	9,654	65,013	11,789,048	5,273,974	2,507,100	647,976	463,906	2,896,092

Table 2.--All live biomass by forest type and stand-age class, Aspen-Birch Unit, Minnesota, 1978

(In thousand green tons)

Forest type	All classes	Stand-age class (years)												
		0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100	101-120	121-140	141+
Jack pine	7,014	628	267	107	1,633	1,328	1,717	735	106	307	59	127	--	--
Red pine	8,042	66	13	93	3,265	485	629	1,212	1,244	882	88	65	--	--
White pine	2,155	--	22	--	--	--	--	356	466	82	799	430	--	--
Balsam fir	27,796	911	1,271	1,833	4,012	9,483	5,976	2,437	553	584	234	502	--	--
White spruce	2,134	103	414	32	211	457	283	50	458	89	--	37	--	--
Black spruce	28,193	631	2,424	3,585	3,917	2,902	3,730	2,872	3,344	2,438	1,556	314	480	--
Northern white-cedar	13,461	240	218	476	585	1,032	959	1,438	1,549	1,835	1,018	1,700	2,411	--
Tamarack	4,162	164	498	765	237	441	423	362	277	285	40	481	156	33
Oak	372	--	--	--	58	190	124	--	--	--	--	--	--	--
Elm-ash-cottonwood	10,343	312	475	233	348	1,101	1,699	1,675	919	1,388	1,090	532	571	--
Maple-basswood	12,304	180	473	158	619	1,907	2,033	789	2,329	836	1,539	858	583	--
Aspen	95,065	4,659	5,422	5,936	12,330	22,845	24,453	10,106	4,611	2,187	2,106	383	--	27
Paper birch	29,490	678	874	1,164	2,271	7,480	9,471	3,867	2,519	767	288	111	--	--
Balsam poplar	9,850	331	292	308	1,812	3,150	1,663	994	837	357	106	--	--	--
Nonstocked	410	410	--	--	--	--	--	--	--	--	--	--	--	--
All types	250,791	9,313	12,663	14,690	31,298	52,801	53,160	26,893	19,212	12,037	8,923	5,540	4,201	60

Table 3.--All live biomass by species and diameter class, Aspen-Birch Unit, Minnesota, 1978

(In thousand green tons)

Species	All classes	Diameter class (inches) 0.0-2.9	3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9
SOFTWOODS:								
White pine	3,199	13	93	103	211	224	489	371
Red pine	7,276	44	534	500	1,031	1,584	1,243	854
Jack pine	7,624	34	314	1,013	1,842	2,283	1,212	506
White spruce	4,865	254	685	554	650	721	674	457
Black spruce	25,383	2,634	10,339	6,363	3,929	1,430	440	149
Balsam fir	36,008	3,845	11,025	8,706	6,646	3,776	1,430	456
Tamarack	5,555	389	1,790	1,426	1,111	476	263	62
Northern white-cedar	11,483	751	3,117	1,310	1,762	1,750	1,153	738
Other softwoods	47	10	17	6	3	8	--	3
Total	101,440	7,974	27,914	19,981	17,185	12,252	6,904	3,596
HARDWOODS:								
Select white oaks	348	13	36	46	48	47	54	18
Select red oaks	623	11	50	70	78	122	122	83
Other red oaks	--	--	--	--	--	--	--	--
Hickory	--	--	--	--	--	--	--	--
Yellow birch	920	7	28	25	45	48	184	133
Hard maple	6,087	563	1,406	1,133	854	561	382	331
Soft maple	4,715	723	1,790	832	673	323	159	101
Ash	11,270	983	2,272	2,329	2,054	1,665	966	519
Balsam poplar	11,546	426	1,484	1,436	2,425	2,192	1,597	1,019
Paper birch	39,436	1,739	6,828	8,830	9,977	6,478	3,145	1,250
Bigtooth aspen	1,533	16	106	158	260	307	337	135
Quaking aspen	67,959	2,946	6,712	10,105	14,478	14,129	9,531	5,747
Basswood	1,557	24	162	207	285	325	161	108
Elm	2,675	54	195	210	277	308	343	308
Select hardwoods	31	13	14	4	--	--	--	--
Other hardwoods	117	11	53	12	14	10	8	--
Noncommercial species	534	332	126	51	15	6	4	--
Total	149,351	7,861	21,262	25,448	31,483	26,521	16,993	9,752
All species	250,791	15,835	49,176	45,429	48,668	38,773	23,897	13,348

(Table 3 continued on next page)

(Table 3 continued)

Species	Diameter class (inches) 15.0-16.9	17.0-18.9	19.0-20.9	21.0-22.9	23.0-28.9	29.0-38.9	39.0+
SOFTWOODS:							
White pine	333	287	250	268	370	150	37
Red pine	580	433	297	114	62	--	--
Jack pine	245	137	24	10	4	--	--
White spruce	406	188	151	92	33	--	--
Black spruce	63	25	9	2	--	--	--
Balsam fir	102	13	9	--	--	--	--
Tamarack	26	12	--	--	--	--	--
Northern white-cedar	416	232	147	43	59	5	--
Other softwoods	--	--	--	--	--	--	--
Total	2,171	1,327	887	529	528	155	37
HARDWOODS:							
Select white oaks	36	12	5	--	28	5	--
Select red oaks	55	16	16	--	--	--	--
Other red oaks	--	--	--	--	--	--	--
Hickory	--	--	--	--	--	--	--
Yellow birch	82	114	81	71	91	11	--
Hard maple	379	211	102	60	105	--	--
Soft maple	57	38	7	12	--	--	--
Ash	294	106	50	9	23	--	--
Balsam poplar	515	308	74	51	19	--	--
Paper birch	619	303	124	66	77	--	--
Bigtooth aspen	138	50	15	11	--	--	--
Quaking aspen	2,362	1,130	524	173	122	--	--
Basswood	113	79	47	31	15	--	--
Elm	265	258	114	119	155	48	21
Select hardwoods	--	--	--	--	--	--	--
Other hardwoods	2	5	2	--	--	--	--
Noncommercial species	--	--	--	--	--	--	--
Total	4,917	2,630	1,161	603	635	64	21
All species	7,088	3,957	2,048	1,132	1,163	219	58

☆ U.S. GOVERNMENT PRINTING OFFICE: 1981—766-853